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ABSTRACT

A study examined the influence of extended analogies on the comprehension of unfamiliar texts by primary grade children. Subjects, 16 first- and 16 third-grade children, listened to two passages that described how the blood circulates in the body and how an infection heals. The passages were presented either with or without analogies. The children were asked to recall the information contained in the passages and to answer a number of factual and inferential questions. Results showed that at each grade level, the analogy group performed better than the no analogy group. The children made certain kinds of inferential errors, such as attributing human feelings and emotions to inanimate things, but these occurred irrespective of the presence or absence of analogies. The results suggest that analogy can be an effective mechanism for transferring knowledge from a familiar to an unfamiliar domain, a mechanism that not only adults but also children can use effectively. (The passages used in the study are appended.) (Author/FL)

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Technical Report No. 291

THE INFLUENCE OF ANALOGY IN CHILDREN'S
ACQUISITION OF NEW INFORMATION FROM TEXT:
AN EXPLORATORY STUDY

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Abstract

The influence of extended analogies on the comprehension of unfamiliar texts by elementary school children was investigated. First and third grade children were read two passages that described how the blood circulates in the body and how an infection heals. The passages were presented either with or without analogies. The children were asked to recall the information contained in the passages and to answer a number of factual and inferential questions. Results showed that at each grade level the Analogy group performed better than the No Analogy group. The children made certain kinds of inferential errors, such as attributing human feelings and emotions to inanimate things, but these occurred irrespective of the presence or absence of analogies. The results of this experiment suggest that analogy can be an effective mechanism for transferring knowledge from a familiar to an unfamiliar domain, a mechanism which not only adults but also elementary school children can effectively utilize.

The Influence of Analogy in Children's Acquisition of New
Information from Text: An Exploratory Study

The question of how children acquire new knowledge, and more specifically how they acquire new knowledge from text, is a particularly important one and yet it is one that has been relatively neglected. Typically, our models of comprehension stress the importance of prior knowledge in understanding text and in learning. But what happens when a new subject is introduced, one about which the reader has little prior knowledge? This problem appears to be particularly acute within the context of schema-based theories (e.g., Adams & Collins, 1979; Rumelhart & Ortony, 1977; Schank & Abelson, 1977). Insofar as such theories assume that, rather than operating on the basis of content-free general inference rules, reasoning is tied to particular bodies of knowledge and is context-bound, it is not easy to see how old knowledge can transfer to new domains.

One solution to the problem lies in the use of analogy and metaphor. Indeed, a number of researchers (e.g., Carbonell, Note 3; Hayes & Tierney, 1982; Rumelhart & Norman, 1981; Schustack & Anderson, 1979) have argued that the way people commonly bridge knowledge learned in one domain with knowledge learned in another domain is through analogical reasoning. Analogies and metaphors help structure a new domain in the mold of a previously known one; consequently, they can function as important mechanisms in the acquisition of new knowledge.

This claim has received some support in the case of adult or adolescent subjects (Hayes & Tierney, 1982; Schustack & Anderson, 1979). There is no research, however, that shows whether or not elementary school

children can use analogy as a mechanism for transferring knowledge from an old to a new domain. Yet, the answer to this question can have important implications both with respect to the texts that elementary school children read, and with respect to teaching methods. For instance, while examples of the use of analogy to help structure unfamiliar domains abound in the case of adult text, analogies are practically nonexistent in the elementary school child's content area textbooks. Surveys of elementary school textbooks (e.g., Dixon, Ortony & Pearson, Note 1) show that although figurative language is used in basal reading series, metaphors and analogies are almost completely absent from content area textbooks.

It might be that authors of such texts fear that elementary school children would not be able to properly understand metaphors and analogies; while it might be all right to miss a figure of speech in a narrative, it is not all right to risk misunderstanding a whole passage by introducing a new and unfamiliar topic in terms of an analogy. Such concerns are understandable. A number of studies have shown that children do not comprehend metaphorical language until middle childhood or early adolescence (Asch & Nerlove, 1960; Winner, Rosenstiel & Gardner, 1976; Cometa & Eson, 1978). However, such studies suffer from important methodological problems. When these problems are corrected, young children are found to be able to comprehend metaphorical uses of language. For example, in our work (Vosniadou & Ortony, 1983; Vosniadou, Ortony, Reynolds & Wilson, in press), we have shown that even 4-year-old children can understand metaphorical language under some circumstances, i.e., when the items being compared are familiar to the children, when the metaphorical

language is embedded in some linguistic or situational context, and when comprehension is measured by enactments rather than by paraphrases.

The focus of the present research was not to investigate further whether children can understand analogies or not. Rather it was assumed that elementary school children know that language is sometimes used nonliterally. The purpose of this study was to investigate whether elementary school children could use an analogy to facilitate their acquisition of new information from text. More specifically, two related questions were asked: First, do children learn more about a relatively unfamiliar domain (the topic domain) if it is described in terms of an analogy drawn from a familiar domain (the vehicle domain) than if it is not? For example, does thinking of an infection (topic domain) as an invasion by an enemy (vehicle domain)--the bacteria being the enemy forces and the white blood cells being the body's soldiers--facilitate children's understanding of infection? Second, if children are indeed able to transfer knowledge from a more familiar domain to a less familiar domain, do they know which aspects of the familiar domain are appropriate to transfer and which are not? We know from prior research (Gentner, in press; Rumelhart & Norman, 1981), that adults sometimes make transfer errors when they are instructed about a new topic through an analogy drawn from a familiar domain. However, while even adults sometimes draw such erroneous inferences, they do not usually make certain kinds of transfer errors that children might make. For example, adults do not usually transfer physical/descriptive characteristics from the vehicle domain to the topic domain, but children may.

Method

Subjects

Thirty-two children, 16 first graders and 16 third graders from a Central Illinois public school, participated in this study. The children represented a range of ability levels and ethnic backgrounds.

Design and Materials

The design was a $(2 \times 2) \times (2)$ factorial design with Grade (first vs third grade) and Group (Analogy vs No Analogy) as between subject variables, and Passage Type (Blood Circulation vs Infection) as a within subject variable.

The materials consisted of two passages, both of which described aspects of "how the body works." One passage described "how the blood circulates in your body" (the Blood Circulation passage) and the other described "how an infection heals" (the Infection passage). Each passage was written in two versions: an "Analogy" version and a "No Analogy" one. Both the Analogy and the No Analogy versions of the passages contained the same factual information. The main difference between them was in the presence or absence of analogies. The two passages are presented in Table 1. They were both about 300 words long, with the two versions being approximately similar in length. This was achieved by repeating or embellishing some of the information presented in the No Analogy passage.

Insert Table 1 about here.

There were 10 factual and 10 inferential questions asked for each passage. These questions were the same for the Analogy and No Analogy passages. The factual questions tested the childrens' understanding of the

main ideas described in the passage. The inferential questions investigated four types of possible transfer errors from the familiar to the unfamiliar domains. One question type investigated whether children were likely to transfer physical characteristics and activities usually associated with the vehicle domain to the topic domain. For example, given the invasion by an enemy as the vehicle domain and the infection as the topic domain, the children were asked if white cells use weapons to kill the germs, or if they wear uniforms. A second question type investigated the possible transfer of thoughts and feelings from the vehicle domain to the topic domain. In this case the children were asked if the white blood cells are brave, if they are frightened when fighting the germs, and so on. It was hypothesized that if the children in the Analogy group were inappropriately transferring physical properties and feelings from the vehicle to the topic, they would be more likely to answer these questions affirmatively than the children in the No Analogy group. A third type of inferential question investigated transfer of plans and goals from the vehicle to the topic domains, while a fourth type investigated transfer of causal consequences. In those cases the children were asked questions of the sort "what would happen if many white cells died fighting the germs?" Again it was hypothesized that if the children in the Analogy group were inappropriately transferring properties of the vehicle to the topic they would be more likely than the children in the No Analogy group to give answers like "the body should get guns to fight the enemy" or "the battle would be lost."

Procedure

The children were randomly assigned either to an Analogy or No Analogy group. They were tested individually. All children listened first to Passage 1 which was read to them twice. They were then asked to recall it and answer the factual and inferential questions. This procedure was repeated for Passage 2.

Scoring

Each passage was divided into a set of 22 distinct content units. These content units are shown in Table 1, where each sentence in a parenthesis represents such a unit. Each content unit represented a piece of factual information which appeared in both the Analogy and the No Analogy version of each text. Analogies (or parts of them) were not scored as additional content units because the children were tested only on information that appeared in both versions of the passages. Two independent judges used these content units to score the recalls. Agreement was high (98%) and the few cases of disagreement were resolved after brief discussion.

Results

An analysis of variance was performed first on the mean proportion of content units recalled. Because the data were proportional and had a binomial distribution, an arc sine transformation was applied to the data. The analysis of variance showed main effects for group, $F(1,28) = 7.33$, $p < .01$, and for age, $F(1,28) = 4.21$, $p < .05$. As expected, the Analogy group recalled more content units than the No Analogy group, and the older children did better than the younger children. Table 2 shows the mean

proportion of content units recalled for the two passages as a function of age and group type. There appear to be more content units recalled from Passage 2 (the Infection passage) than from Passage 1 (the Blood Circulation passage) but the difference was not statistically significant.

Insert Table 2 about here.

An analysis of variance was then performed on the data representing the children's answers to the factual questions. These data showed again that the Analogy group did better than the No Analogy group, $F(1,28) = 6.09$, $p < .01$, but there was no significant main effect for age. Table 3 shows the mean proportion of factual questions answered for the two passages as a function of age and group type.

Insert Table 3 about here.

In addition to the main effect for group there was also a significant main effect for passage, $F(1,28) = 13.92$, $p < .001$, and a significant interaction between passage type and group type, $F(1,28) = 5.19$, $p < .05$. As can be seen in Table 3, children answered more factual questions correctly for Passage 2 than for Passage 1, but the difference was much greater for the Analogy group than the No Analogy group.

The last measure was the children's answers to the 10 inferential questions. The results are shown in Table 4.

Insert Table 4 about here.

The main finding was that the children in the Analogy group answered the inferential questions in very much the same way as the children in the No Analogy group. Practically all the children, regardless of whether they were in the Analogy or the No Analogy group, attributed human-like feelings and thoughts to white blood cells and germs, but answered the remaining questions correctly.

Discussion

The results of this exploratory study indicated that elementary school children recall and answer questions about text with analogies better than texts which contain the same factual information without analogies. These results suggest that analogy can be an effective mechanism for transferring knowledge from a well known to a new domain, a mechanism that not only adults but also first and third grade children can effectively utilize.

One area of concern was the overall low level of recall, particularly of the first graders. This might be attributable in part to the difficulty of the texts used. Furthermore, since the passages were read aloud, failure to concentrate might also have been a contributing factor. There was noticeable individual variation in recall performance. Within both age groups some children did quite well and others quite poorly. However, both groups appeared to profit from the use of the explanatory analogies. The question of individual variation in children's ability to learn new information from text (see Bransford, Stein, Shelton & Owings, 1981; Brown, Bransford, Ferrara & Campione, in press), and the influence of analogy in that context are interesting questions that deserve to be pursued further.

The present findings also suggest that the facilitative effect of analogy does not appear to be something that is constant, but rather something that varies from analogy to analogy. One of the two exploratory analogies used in this study (the infection/invasion analogy) facilitated children's responses to the comprehension questions more than the other. This findings suggests that some analogies may be better than others. Different suggestions have been made, although not in the context of a developmental theory, about what makes some analogies (or metaphors) better (or more apt) than others (see Gentner, in press; Gick & Holyoak, 1980; Tourangeau & Sternberg, 1981; Rumelhart & Norman, 1981). Most of these suggestions center around the idea of "goodness of fit" between the domains compared, either in terms of "closeness of mapping between the two domains" (Tourangeau & Sternberg, 1981), "the number of shared relations" (Gentner, 1982), or "the number of specifiable dimensions" (Rumelhart & Norman, 1981). If such criteria are applied to the two analogies used in the present study, it does indeed appear that the infection/invasion analogy is more powerful than the blood circulation/trains travelling analogy. It should be noted, however, that in this experiment the order of the passages was not counterbalanced. Thus, the possibility that superior performance was due in part to other factors (e.g., task familiarity) cannot be ruled out. Obviously, further research is needed to determine more specifically how analogies work and what makes some better than others.

Finally, the children in the Analogy group were not more likely to draw erroneous inferences about the topic domain on the basis of their knowledge of the vehicle domain than the children in the No Analogy group. Whatever erroneous inferences were drawn appeared to be characteristic of

the way children of this age think in general, rather than a specific effect of the analogies used. In general the children were rather likely to attribute human feelings and emotions to inanimate things. Only two out of sixteen third graders explicitly disqualified the inferential questions enquiring about the cognitive and emotional state of bacteria and white blood cells by saying that germs and white blood cells are not human and they do not feel or think the way humans do. All other children readily said that germs are mean and white blood cells are brave, although they disagreed as to whether the white blood cells were frightened or not while fighting the germs. It is possible that many of the children would admit that such attributions were not appropriate if they were further questioned about their responses and were asked to justify the. There is some research evidence showing that the animate/inanimate distinction is an early achievement (e.g., Keil, 1979; Flavell, Shipstead & Croft, Note 2), although others (e.g., Piaget, 1929; Carey, Note 4) believe that a full understanding of the concept of animacy may take longer to acquire. The results of the present study indicated that there is a natural tendency in children to spontaneously transfer certain properties of the human world--in this particular case feelings and thoughts--to domains that have some human-like properties, particularly if this domain is not a familiar one (see Piaget, 1929). This tendency to anthropomorphize was not related to the analogy but rather appeared to be a very general characteristic of the children's thinking. In fact, rather than saying that the analogy encouraged this kind of thinking, one might say that, possible, one of the reasons why particularly the infection/invasion analogy worked was because

it exploited the children's natural and spontaneous tendency to anthropomorphize and built on this tendency to teach them something new.

It is interesting to note that very few of the children made transfer errors besides those related to human feelings and emotions. Only a couple of first graders showed signs of interpreting the analogy in a rather concrete way and gave answers of the sort that white blood cells fight the germs with guns which they use to shoot them down, or that the cells pay for having food brought to them by the blood. All children, regardless of group, gave appropriate answers to the causal consequences questions, saying, for example, that if many white blood cells died in your body you could get sick and possibly die. Similarly, the children gave mostly appropriate answers to the goals and plans questions, saying, for example, that good food and exercise are needed to keep the body in good condition. Again here, a couple of children interpreted the analogy more concretely. For example, one third grader said that what you need to do to protect your body from infection is to put the germs in jail! Also the children who heard the analogy passage were more inclined to connect their answers with the notion of fighting. For example, one child said that "good food was needed to get strong to fight," and another one said that the food is needed to "make the poison that kills the germs." Finally, an imaginative first grader added that medicine is needed to protect ourselves when we have an infection because "medicine is like water that pours on them and they don't expect it. The (the germs) will be pushed back by water, and they will go down the drain!"

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Table 1

PASSAGE #1

ANALOGY

Blood Circulation

(Your body is like a country.)(1) (Like a country needs food and fuel to feed its people and run its factories, so does your body need food and oxygen to live and grow.)(2) (Food and oxygen are carried to all parts of your body by the blood.)(3)

(Like trains travel on railroad tracks to bring food and fuel to every city and town of a country, so does your blood travel in blood vessels)(4) (to bring food and oxygen to every cell in your body.)(5) (There are almost as many miles of blood vessels in your body as there are miles of railroad tracks in the U.S.)(6)

(The blood's trips start from a central station, just like trains start their trips from a central station.)(7) (This central station is the heart.)(8) (Starting from the heart, the blood makes two separate round trips.)(9) (a short one)(10) (and a long one.)(11)

(On the short trip the blood starts from the right side of the heart and travels to the lungs)(12) (to pick up the fuel it needs, just like a diesel train goes to get diesel fuel. There, the blood picks up oxygen, gets rid of carbon dioxide, and returns to the left side of the heart.)(13) (Filled with a fresh supply of oxygen it is ready for its long trip.)(14)

(On the long trip the blood starts from the left side of the heart and travels through the rest of the body.)(15) (Like trains traveling all over the country, it makes several stops to pick up and drop off things.)(16) (At the small intestine it picks up tiny bits of food.)(17) (at the kidneys it is cleaned of the wastes it carries.)(18) (Finally, through some very small blood vessels, it reaches the individual body cells and gives them food and oxygen, just like trains reach remote towns by leaving the main tracks.)(19) (The blood takes carbon dioxide and other wastes from the cells, and carries it back.)(20)

(Upon its return to the right side of the heart the blood goes back to be refueled.)(21) (It returns to the lungs where it gets rid of its carbon dioxide and gets filled with a new supply of oxygen.)(22)

NO ANALOGY

Blood Circulation

(Your body is a living thing.)(1) (Like all living things need food and oxygen to live and grow, so does your body need food and oxygen to live and grow.)(2) (Food and oxygen are carried to all parts of your body by the blood.)(3)

(The blood flows throughout your body in a continuous stream of blood vessels.)(4) (There are many miles of blood vessels in your body.)(5) (They carry within them the blood with all the food and oxygen and take them to every single cell of your body.)(6)

(The blood's flow always starts from the same place.)(7) (This place is the heart.)(8) (The blood can start its flow either from the right side of the heart and come back to the left side, or from the left side of the heart and come back to the right side.)(9) (When the blood starts from the right side of the heart its flow is a short one.)(10) (When it starts from the left side of the heart its flow is a long one.)(11)

(When the blood starts from the right side of the heart it goes to the lungs.)(12) (There the blood picks up oxygen, gets rid of carbon dioxide and returns to the left side of the heart.)(13) (Filled with a fresh supply of oxygen the blood is ready to bring it to all parts of the body.)(14)

(When the blood starts from the left side of the heart, it goes through the rest of your body.)(15) (As it circulates it picks up and drops off different things.)(16) (At the small intestine it picks up tiny bits of food.)(17) (at the kidneys it is cleaned of the wastes it carries.)(18) (Finally, through some small blood vessels, it reaches the individual body cells and gives them food and oxygen.)(19) (The blood also takes carbon dioxide and other wastes from the cells, and carries it back.)(20)

(Upon its return to the right side of the heart the blood goes back to the lungs.)(21) (There it gets rid of its carbon dioxide and gets filled with a new supply of oxygen.)(22)

Table 1 (Cont'd)

PASSAGE #2

ANALOGY

How an Infection Heals

(An infection is like an invasion by an enemy.)(1) (Like a country can be attacked by an enemy so can your body be attacked by virus germs.)(2) (For example, a cold is an infection)(3) (caused by a virus which invades your body through your nose and often spreads to the throat.)(4) (Or, if you cut yourself,)(5) (harmful germs might enter your skin and cause an infection.)(6) (An infection heals when your body has won its battle with the enemy forces.)(7)

(Your body fights the infection like a country fights the enemy.)(8) (It gathers its army and sends it to the attacked area)(9) (to fight the invader.)(10) (The body's soldiers are the white blood cells.)(11) (Your blood carries many white blood cells to the infected area like trains carry soldiers to the place of attack.)(12) (Because so much blood gathers, the bacteria-infected cut usually appears red and swollen.)(13)

(Once the extra blood is there, the white blood cells work their way out of the blood vessels and into the infected area, and the fight is on.)(14) (The first thing the white blood cells army does is surround the enemy to keep them from spreading any further.)(15) (the white cells form a wall with their own bodies around the germs.)(16) (Inside the wall other white cells attack the trapped germs to destroy them.)(17) (Meanwhile, the germs keep on multiplying.)(18) (so that the fighting is furious and many white cells die before the battle is won.)(19) (The dead bodies of those white cells and of the dead germs are gathered up in the infected area and form the white matter called pus.)(20) (which eventually is drained away.)(21)

(When the white blood cells have destroyed all the invading germs the battle is over and the infection heals.)(22)

NO ANALOGY

How an Infection Heals

(An infection means that some part of your body is not working as well as it should. Something is going wrong.)(1) (Usually, harmful bacteria or virus germs are causing the trouble.)(2) (For example, a cold is an infection)(3) (caused by a virus which affects your nose and often spreads to the throat)(4) (Or, if you cut yourself,)(5) (harmful germs might enter your skin and cause an infection.)(6) (An infection heals when your body has destroyed all the harmful germs that have affected it and starts working again as it did before the infection.)(7)

(Your body deals with an infection as soon as it can.)(8) (It does so by gathering a lot of blood and sending it to the infected area)(9) (to destroy the harmful germs.)(10) (The body's means of dealing with an infection are especially the white blood cells.)(11) (Your blood brings many white blood cells to the infected area.)(12) (Because so much blood gathers, the bacteria-infected cut usually appears red and swollen.)(13)

(Once the extra blood is there, the white blood cells come out of the blood vessels and into the infected area to deal with the harmful germs.)(14) (The first thing the white blood cells do is to prevent the germs from spreading any further.)(15) (They do that by forming a circle around the germs.)(16) (Inside the circle, the white cells try to destroy as many germs as they can.)(17) (Meanwhile, the germs keep on multiplying.)(18) (so the white cell's job is a hard one and many white cells are themselves destroyed before they clear out the germs.)(19) (The white cells and germs that are destroyed are gathered up in the infected area and form the white matter called pus)(20) (which eventually is drained away.)(21)

(When the white blood cells have destroyed all the harmful germs their job is finished and the infection heals.)(22)

Table 2
Mean Proportion of Content Units Recalled

Grade	No Analogy		Analogy	
	Passage 1	Passage 2	Passage 1	Passage 2
1st	.07	.12	.22	.24
3rd	.19	.20	.29	.32

Table 3
Mean Proportion of Factual Questions Answered

Grade	No Analogy		Analogy	
	Passage 1	Passage 2	Passage 1	Passage 2
1st	.22	.27	.31	.49
3rd	.31	.29	.41	.59

Table 4
Mean Proportion of Errors to the Inferential Questions

Inferential Question Type	Analogy		No Analogy	
	1st Grade	3rd Grade	1st Grade	3rd Grade
Descriptive properties/activities	.13	.06	.12	.15
Human-like emotions/thoughts	1.00	1.00	1.00	.75
Causal consequences	.07	.00	.00	.00
Goals and plans	.06	.03	.00	.00